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Hydrology and Earth System Sciences Discussions
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Interactive comment on "Observed variability and trends in extreme rainfall indices and Peaks-Over-Threshold series" *by* H. Saidi et al.

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Answer to Referee #1:

We would like to thankfully acknowledge Referee #1 for providing valuable comments that will signiïňĄcantly contribute to the improvement of our paper.

In the following lines, we have addressed the reviewer requirements point by point.

1. The work is original only in as far as data have been digitised, and I admit this would have been a major effort. However, a fair number of plots (Fig 7, 8, 9) appear to be standard output from R libraries.

We used some output from R to represent results and to show the different steps of our work. In page 6060 line 11 we specified that we used R software for the analysis and in particular for the extraction of the Peak Over Threshold extremes. It's possible to make some modification to the standard graphic output but we think it's important to keep them in this manuscript and we can mention the name of the packages (like Generalized Pareto Distribution and Peaks Over Threshold Package) in the revised version

2. A map would be needed to indicate the location of stations relative to orographic barriers and how closely sites are located to each other. (It would also be helpful to provide the location of sites in Table 1 in terms of latitude and longitude.) Is the rainfall regime at these locations similar (i.e. could they be assessed jointly) or rather different (i.e. is there potential for different meaningful trends)?

We agree in general with the reviewers comment that a map is important to indicate the location of the four stations. Figure 1 will be added to the revised version. As suggested by the reviewer the location of the sites in table 1(supplement file) will be in terms of latitude N and longitude E:

We will also add some information about rainfall regimes in the section “Data” to the revised version. This information will be a useful tool to understand the different rainfall regimes in a region and can confirm that it's possible to have different significant trends and it's important to analyse the four stations separately: “The hydrologic regime of the Piedmont region is characteristic of pre-alpine environment. On average, this area has a typical regime of northern Italy characterized by two maxima in spring and autumn and two minima in winter and summer. Based on the analysis of long precipitation series in Piedmont, we can distinguish the following regimes (Acquaotta and Fratianni, 2013): - Lombriasco and Bra shows a pre-alpine rainfall regime with a main minimum in winter, a main maximum in spring and a secondary maximum in autumn. The average precipitation of this region is about 780 mm . - Vercelli Shows a Subalpine rainfall regime with 826 mm of annual average rainfall, a main minimum in winter, a main maximum in autumn and a secondary maximum in spring. - Pallanza has a typical behaviour of alpine area. The rainfall regime is defined as “sub-littoral alpine” (Saidi et al., 2012), characterized by high precipitation, about 1700 mm/year (1951-1986), with a main minimum in summer, a main maximum in autumn and a secondary maximum in spring.”

3. The focus is firmly on trend detection. Little attempt is made to interpret the findings or even list the magnitude of the trends that were found to be statistically significant. The figures don’t always support the findings stated in the text: It is difficult to interpret Fig 4a simply in terms of an increasing trend.

We will add table 2 indicating the magnitude of the trends that were found to be statistically significant using a Sen Slope estimation (Sen, 1968) to the revised version. It’s difficult to interpret Fig 4a in terms of an increasing trend because the magnitude of the trend is very low. We present in table 2(supplement file) the results of the Mann-kendall test (only for indices where we observed meaningful trend).

4. There is not really an attempt to define ‘non-stationarity’. However, it is implied that this really only refers to trends. Aren’t rainfall extremes in Italy affected by wet/dry decades (Brugnara, Brunetti, Maugeri, Nanni, & Simolo, 2012)?

It’s known that a time series is stationary “if it is free of trends, shifts, or periodicity, implying that the statistical parameters of the series (e.g., mean and variance) remain constant through time.” (Salas, 1993). Brugnara et al. analysed nine decades of daily precipitation over Europe’s central Alps. In our case, we need longer historical series to study decadal oscillation in rainfall extremes. In this manuscript, statistical analyses have been used for trend detection. To study the effect of wet/dry decade, may be we have to add some indices to the existing list like: Maximum number of consecutive wet (or dry) period and the mean of wet (or dry) period length (Schmidli and Frei 2005). There is also the possibility to compare the cyclic or oscillation patterns with the oceanic or atmospheric oscillation phenomena. For instance the stationarity definition adopted is the one presented by Salas (1993) and in future this research will

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be built upon to further analyse the multidecal oscillation of rainfall extremes.

5. The results appear fairly inconclusive but this could be due to the way they are summarised (under 5 Conclusions). Given the number of indices, durations and sites it is obviously not possible to discuss all combinations in the text, instead it would be helpful to summarise results in tables and/or diagrams.

We agree in general with the reviewer comment that it was difficult to discuss all combinations. In totally we have 4 stations, 10 time scales and 8 indices. For that reason we summarise results in a table 2; we selected time scales and indices showing in general significant trend. The absence of an index or a time scale in this table means that the application of the test confirmed the lack of significant trends.

6. How do the authors explain the fact that there is a significant increase in the 12-h annual maxima at Bra (Fig 2) but judging by Figure 11 quantile estimates (based on GPD) are lower for the later than for the earlier period?

"Figure 2" in the manuscript shows significant increase in the 12h annual maxima at Bra and "figure 11" shows that POT series are lower for the later then the Earlier Period. To explain this we have to interpret figure 2 (below). This figure is presenting the percentage difference between magnitudes for 10 year sliding windows and the long term average. The extreme events were reduced for a period around 1950 and 1960. After that period the magnitude of these events has increased. In addition, magnitudes for the 1970s and 1990s are judged higher than the long term average. The later period 1990s and early 2000s the magnitude of events appears to have increased but not similar to the previous period (1970s, more than 10%) Maybe this can justify the fact that the application of trend test (Mann Kendall) shows a significance increase while POT series shows that quantile estimates are lower for the later (1984-2003) than the earlier period. We can clarify it in a revised version.

7. Reference is being made to impacts on water resource management due to changes in 1h precipitation extremes. Wouldn't longer duration extremes be more relevant?

In page 6059 line 22 we mentioned that "Changes and increase of extreme precipitation frequency coincide with decrease of storm intensity in the case of heavy hourly precipitation registered in Bra (Fig. 6). This may pose a number of problems for water resource managers." We want to explain that studying and analysing precipitation with sub-daily and high temporal resolution (i.e. hourly and sub-hourly) is important for the water resource management and not only 1-hour precipitations. Longer durations are also relevant.

8. No attempt has been made to assess the significance of changes in quantile estimates from the earlier to the later period (for instance by constructing confidence intervals). What is referred to as 'growth curves' are in fact 'frequency curves' (Figure 9 onwards).

We agree with the reviewer comment that what is referred to as "growth curves" are in fact "frequency curves". In fact, for our statistical analysis we prepared two graphs (growth and frequency curves) and only frequency one were used in this manuscript. We estimate the lower and upper limits of a specified confidence interval using Bootsrap method. Frequency curves with 95% confidence intervals are shown in figures 3-4-5-6-7-8.We will insert this figures in a revised version of the manuscript.

9. At times it is difficult to understand the meaning of a sentence (for example line 5 page 6061) to the extent that it becomes difficult to follow the argument that is being presented.

With this statement we want to emphasize on the fact that for short precipitation events (from 5min to 60min) increased in the last 20yr (blue line is upper than red one, figure 9 to 11) and in other side these events decreased for long duration (12-h) (blue line is lower than red one, figure 9 to 11). In a revised version of the Manuscript we will change line 5 page 6061 by: "The more the time scale becomes greater (going from 5 min to 12-h), the more the POT series related to the events recorded in the last 20 yr (blue line in figure 9, 10 and 11) approaches those obtained from the long time series

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(red line in figure 9, 10 and 11) until arriving to a time scale of 12 h where we noticed a decrease of these recent events in comparison with the past (Fig. 11)."

References

Acquaotta, F. and Fratianni, S.: Analysis on Long Precipitation Series in Piedmont (North-West Italy), American Journal of Climate Change., Vol. 2 No. 1. 14-24. doi: 10.4236/ajcc.2013.21002, 2013.

Salas, J.D.: Analysis and Modelling of Hydrologic Time Series in Handbook of Hydrology, D.R. Maidment Editor, McGraw Hill Inc., New York, 1993.

Schmidli, J. and Frei, C.: Trends of heavy precipitation and wet and dry spells in Switzerland during the 20th century. Int J. Climatology., 25:753-771, 2005.

Sen, P.K.: Estimates of the regression coefficient based on Kendall's tau, Journal of the American Statistical Association., 63, 1379-1389, 1968.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/10/C3740/2013/hessd-10-C3740-2013-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 6049, 2013.

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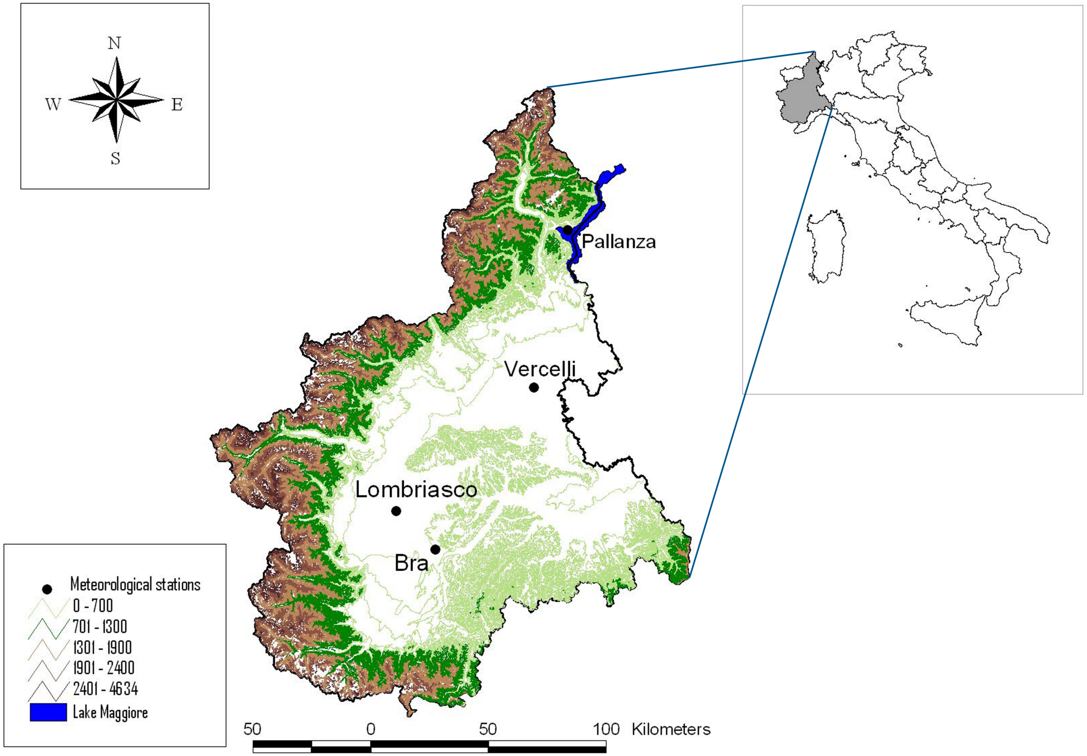

Fig. 1. Study area and spatial distribution of the stations

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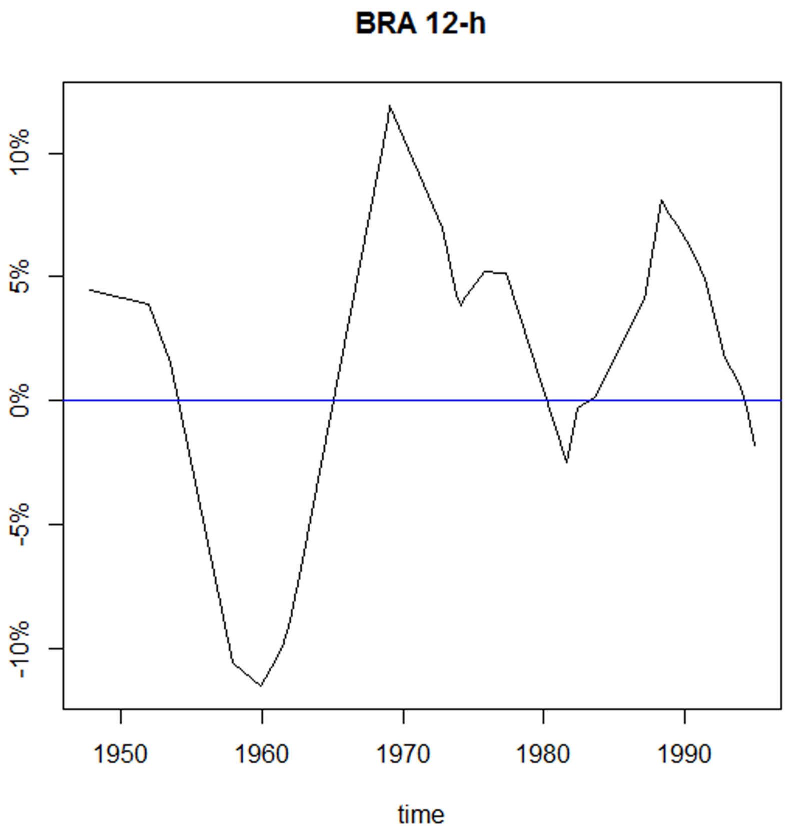

Fig. 2. Percentage differences between magnitudes for 10 year sliding windows and the long term average

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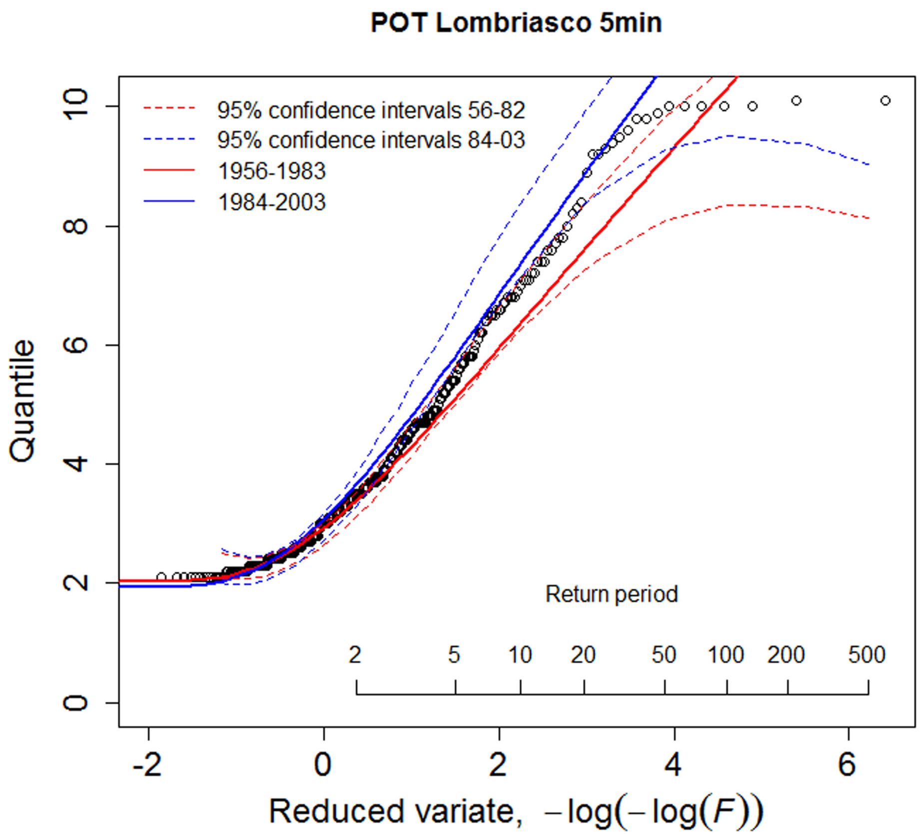

Fig. 3. Changes in POT series of 5min duration compared to the last 20 yr: Lombriasco

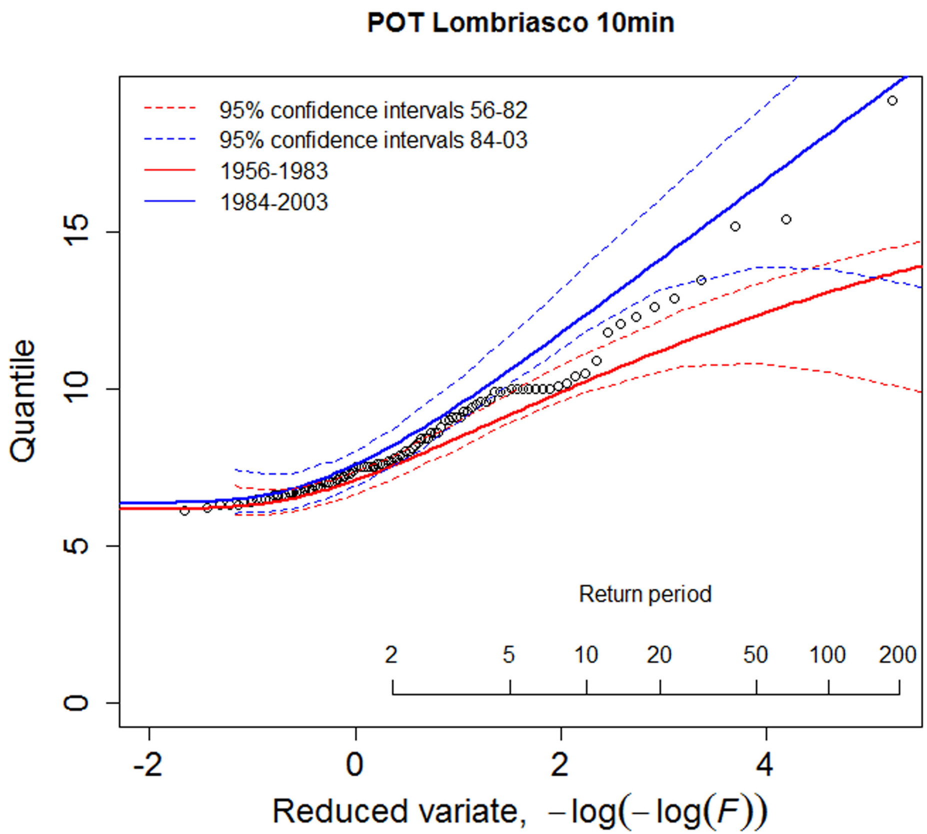

Fig. 4. Changes in POT series of 10min duration compared to the last 20 yr: Lombriasco

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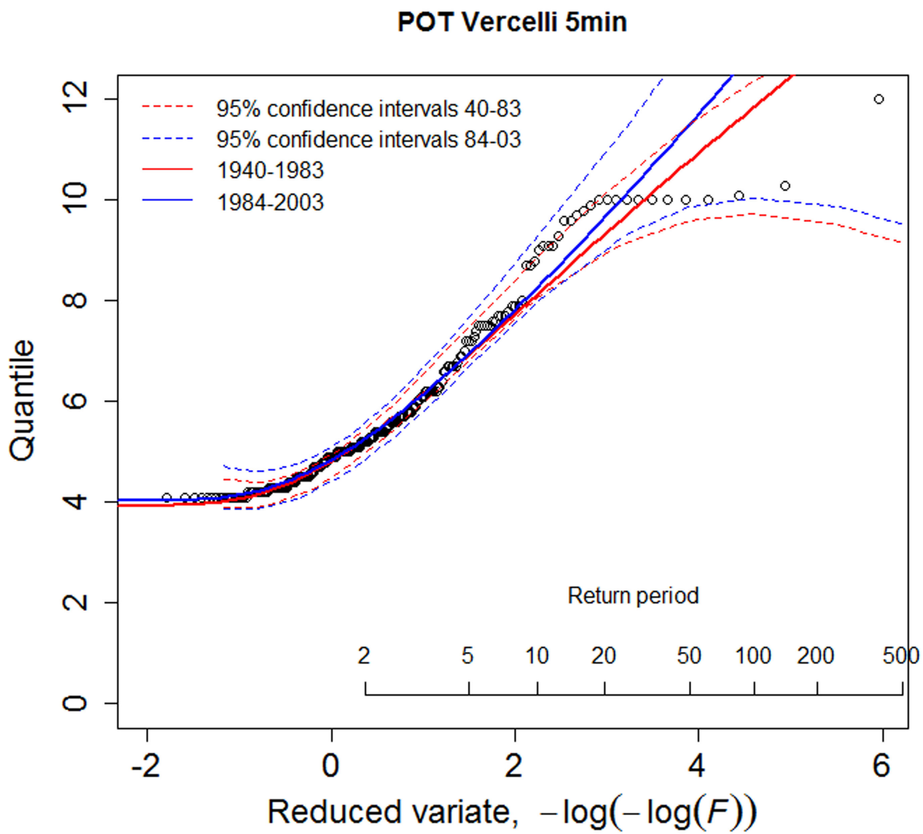

Fig. 5. Changes in POT series of 5min duration compared to the last 20 yr: Vercelli

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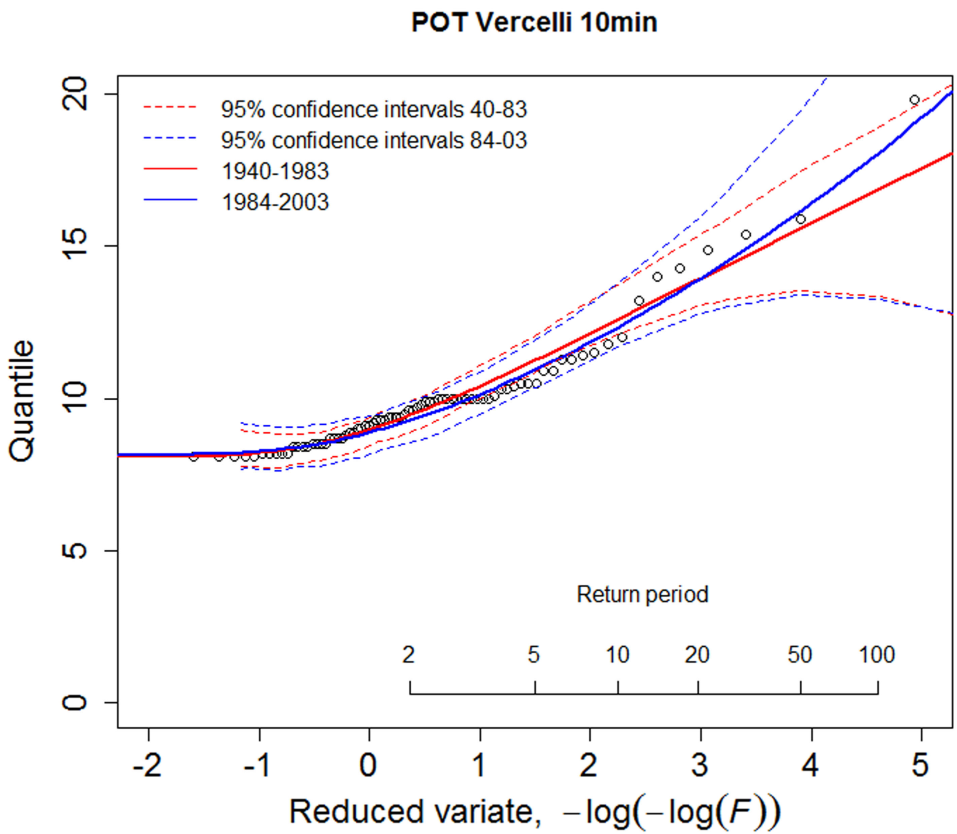

Fig. 6. Changes in POT series of 10min duration compared to the last 20 yr: Vercelli

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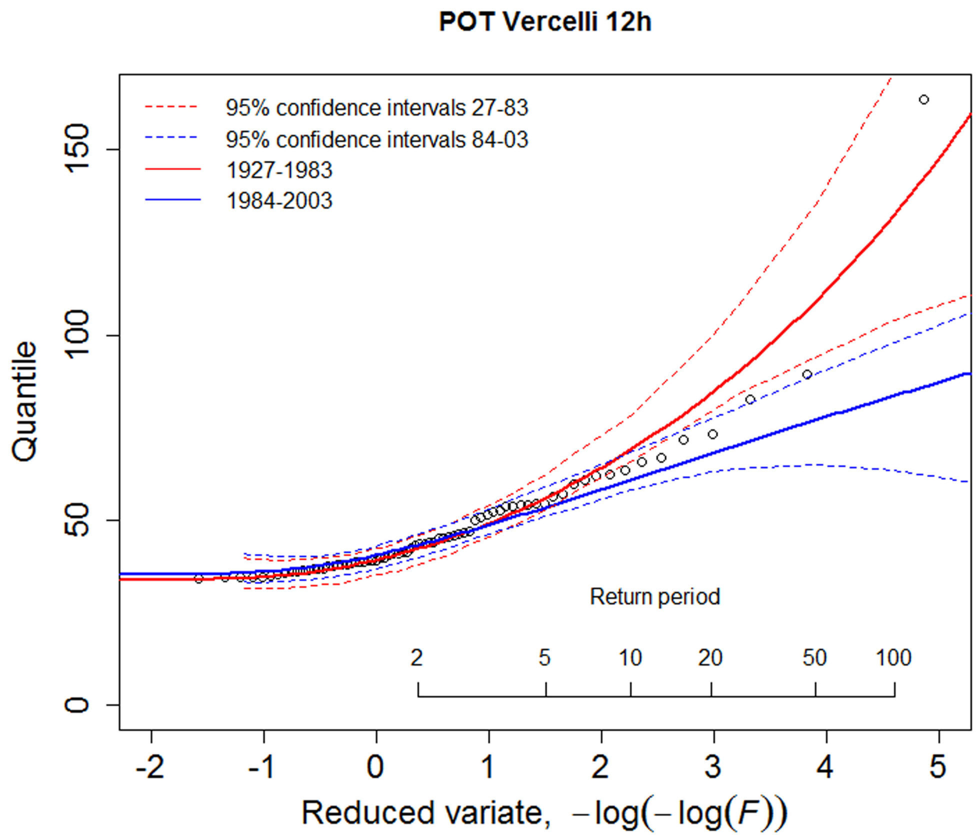

Fig. 7. Changes in POT series of 12h duration compared to the last 20 yr: Vercelli

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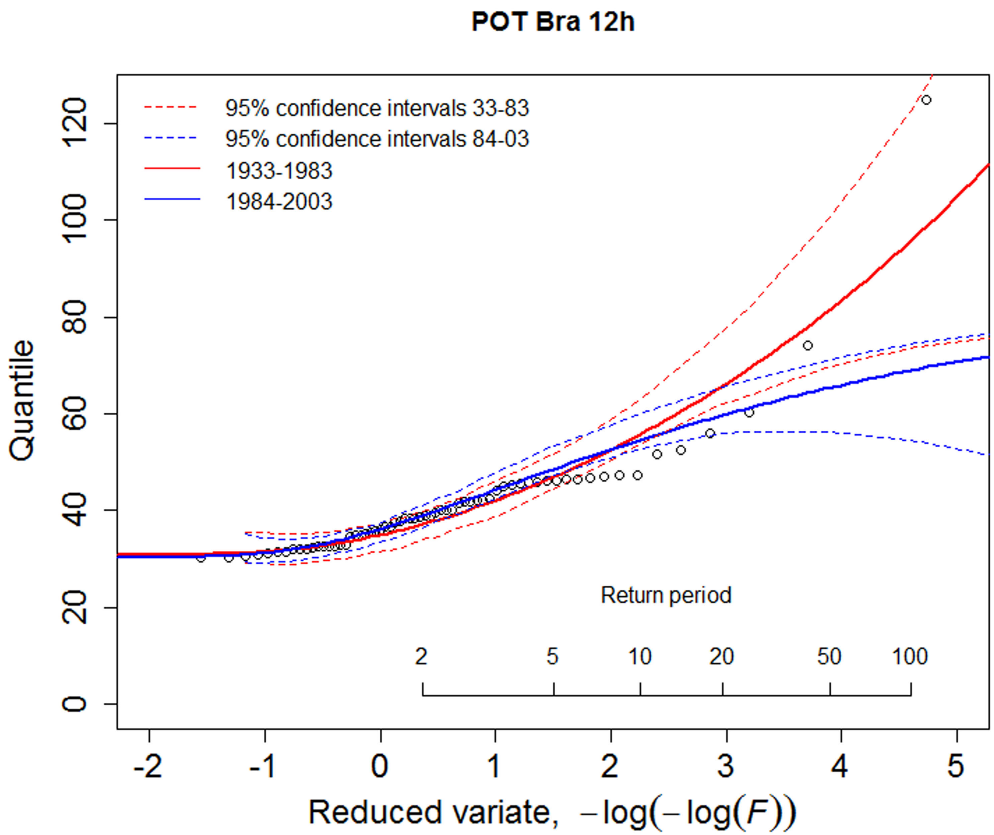

Fig. 8. Changes in POT series of 12h duration compared to the last 20 yr: Bra

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Table 1. Main characteristics of meteorological station:

Station name	Elevation m a.s.l	Location		Observation period Year
		Latitude (N)	Longitude (E)	
Bra	290	44° 04' 18"	7° 51' 09"	1933-2003
Vercelli	135	45° 19' 32"	8° 23' 26"	1927-2003
Lombriasco	241	44° 53' 14"	7° 41' 15"	1939-2003
Pallanza	211	45° 55' 36"	8° 32' 56"	1950-1991

Table 2. Results of the application of the Mann-Kendall test:

Station	time scale	Indice	Trend (unit/100 year)
Vercelli	1h	extreme intensity	+1.3
		extreme frequency	**+4**
		Spring	+1.5
Pallanza	30min	extreme intensity	**+18**
		extreme frequency	**+24**
		Spring	+1
Lombriasco	20 min	extreme intensity	**+1.6**
		extreme frequency	+11
		Spring	+1.3
	3h	extreme intensity	+2.12
		extreme frequency	**+6**
		Spring	**+8.6**
	6h	extreme intensity	+7.4
		extreme frequency	**+2**
		Spring	**+14.8**
Bra	1h	extreme intensity	**-1.8**
		extreme frequency	**+12**
		Spring	+4
	2h	extreme intensity	+4.27
		extreme frequency	**+6**
		Spring	+5.7
	3h	extreme intensity	+5.12
		extreme frequency	**+5**
		Spring	**+8.3**
	6h	extreme intensity	**+9**
		extreme frequency	**+2**
		Spring	**+10**
	12h	extreme intensity	**15.9**
		extreme frequency	0
		Spring	**14.1**

Bold numbers: signifance level grater than 95%
Unit = mm in case of Spring and extreme intensity index
Unit = event in case of extreme frequency index

Fig. 9. Tables

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